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PCT No. PCT/EP85/00259 Sec. 371 Date Feb. 5, 1986 Sec. 102(e) Date Feb. 5, 1986 PCT Filed May 31, 1985 PCT Pub. No. WO85/05653 PCT Pub. Date Dec. 19, 1985.A prefabricated support and covering structure for making artificial tunnels, small bridges, and the like, is comprised of a plurality of modular bodies each of which consists of a plurality of prefabricated reinforced concrete panels interconnected by reinforcing rods so that upon lifting of the center portion of each modular body the prefabricated panels will fold about hinges defined by the reinforcing rods. The reinforcing rods are disposed at angles relative to each other and intersect along a line parallel to the axis of the structure, which line defines the hinge axis. Each prefabricated panel of reinforced concrete has abutting edges and the gap between the confronting faces of the panels is filled with binding material. The modular bodies are each provided with lateral flanges to define a space between the lateral spaces of adjacent bodies which is also filled with a binding material to unite the modular bodies to each other.

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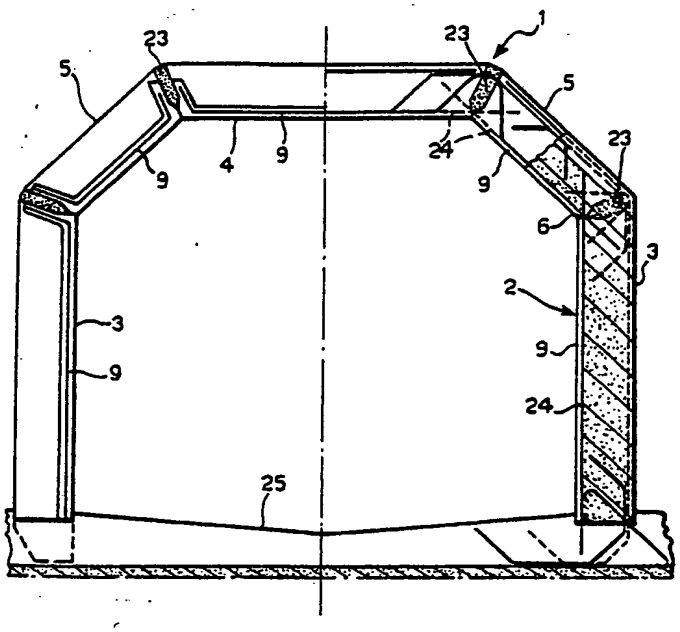
(54) Title: PREFABRICATED SUPPORT AND COVERING STRUCTURE, PARTICULARLY FOR CONSTRUCTING TUNNELS, BRIDGES AND THE LIKE

(57) Abstract

A prefabricated support and covering structure for constructing artificial tunnels small bridges and the like. The structure (1) is formed by placing a number of modular bodies (2) having the shape of a polygonal sector side-by-side in succession; these modular bodies are arranged along the longitudinal axis of the structure. Each modular body (2) is constituted by at least one prefabricated element including two or more panels (3, 4, 5) of reinforced concrete placed in succession along the polygonal line which defines the cross-section of the prefabricated structure. A plurality of connecting and reinforcing rods (7) extend from each panel to the adjacent panel close to the convex outer surface of the prefabricated structure. The adjacent panels (3, 4, 5) of each prefabricated element have on their respective adjacent end faces a front edge (6) substantially parallel to the longitudinal axis of the prefabricated structure and disposed in proximity to the concave inner surface (9) of the latter. The two front edges (6) of each pair of respective adjacent panels are substantially in longitudinal contact with each other so as to define, with the adjacent surfaces of the said end faces, a longitudinal space (23) filled with a binding material cast on site; means are provided for connecting together the adjacent prefabricated elements of the adjacent modular bodies (2) so as to form the entire prefabricated support and covering structure.



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Prefabricated support and covering structure, particularly for constructing tunnels, bridges and the like

The invention relates to prefabricated support and cover structures, particularly for making tunnels, bridges and the like. More precisely the invention relates to prefabricated structures including a number of modular bodies of polygonal sector shape disposed side-by-side in succession along the longitudinal axis of the structure.

The problem which arises in structures of the aforesaid kind is that of making modular bodies, at least partly prefabricated, which can be handled, which are easy to install on site and which are predisposed so as to form, when assembled, a solid and monolithic structure.

Some structures used in the field of construction of artificial tunnels, small bridges and the like envisage the prefabrication of only the roof panels, with the disadvantage of having to cast on site the piers, that is, the pillars and/or lateral support walls. Other structures envisage separate prefabrication of the roofs and piers; in this case it proves particularly difficult to achieve satisfactorily and economically a rigid connection between the roof and piers; more commonly, in fact, use is made of covers which simply rest on the piers, even though much greater thicknesses and reinforcements are needed. Apart from the above, other structures are also available in which the modular bodies are prefabricated in a single monolithic element and thus have smaller thicknesses; such modular bodies are, however, difficult to transport, so that it is practically impossible to use them to build structures of relatively large dimensions.

The object of the present invention is to provide

a prefabricated support and covering structure, particularly for constructing artificial tunnels, small bridges and the like, which does not have substantially the disadvantages previously mentioned and allows the construction of very solid structures, of relatively large dimensions, using modular bodies which are almost completely prefabricated and at the same time easily transportable.

With a view to achieving this object the invention provides a prefabricated support and covering structure particularly for building artificial tunnels, small bridges and the like, comprising a plurality of modular bodies in the shape of polygonal sectors, arranged side-by-side in succession along the longitudinal axis of the structure, characterised in that each modular body is constituted by at least one prefabricated element comprising two or more panels of reinforced concrete disposed in succession along the polygonal line which defines the cross-section of the prefabricated structure, each panel being connected to the adjacent panel by articulation means and means for reciprocal positioning, the articulation means consisting of a plurality of connecting reinforcement rods extending from each panel to the adjacent panel.

The invention will now be described with reference to a preferred practical embodiment ilustrated in the appended drawings, supplied purely by way of non-limiting example, in which:

Figure 1 is a perspective view of a prefabricated support and covering structure according to the invention;

Figure 2 is a front view, partially in section, taken along the line II-II of the structure of Figure 1;

Figure 3 is a perspective view of a component of Figure 1 illustrated on site, before erection;

Figure 4 is a lateral view in the direction of the arrow IV in Figure 3;

Figure 5 is a view on an enlarged scale of a detail of Figure 4;

Figure 6 and Figure 7 are sections taken along the lines VI-VI and VII-VII respectively in Figure 4;

Figures 8, 9, 10, 11 are diagrammatic views of a device for lifting the component in Figure 3, arranging it in its final assembly form and installing it on site, illustrated in various successive operational stages;

Figures 12 and 13 are sectional views taken along the lines XII-XII and XIII-XIII in Figure 1, and

Figure 14 is a variant of Figure 2.

Indicated as 1 in its entirety is a prefabricated support and covering structure, particularly suitable for building artificial tunnels, small bridges and the like, such as, for example, underground passages, covered ducts, box structures etc. The structure 1 consists of a plurality of modular bodies 2 disposed in succession, each in the form of a half-ring consisting of a polygon with five sides. The structure 1 has, consequently, a polygonal cross section

corresponding to that of the adjacent modular bodies 2.

Each modular body 2 is formed by a prefabricated element comprising five prefabricated panels forming the five sides of the aforesaid polygon. The outermost panels indicated at 3 constitute on site the side walls of the prefabricated structure. The centre panel 4 and the intermediate panels 5 constitute the roof on site. Each modular body 2 is prefabricated under such conditions that the five panels indicated as 3, 4 and 5 are arranged in substantial alignment along a straight line as indicated in Figures 3 and 4.

In this way the modular body 2 is more easily made and is very easily transportable.

Each panel includes a base wall 9, which on site constitutes the inner concave surface of the prefabricated structure, and two transverse ribs 10 disposed adjacent the lateral edges of the panel. Within the aforesaid ribs, in proximity to the edge opposite the wall 9, there are disposed reinforcing rods indicated at 7 which extend from one panel to the adjacent panel, constituting the sole connection between them. The portions 7a of the rods 7 which are interposed between two adjacent panels are inclined to each other and so disposed as to intersect on a common straight line, indicated 8, substantially parallel to the longitudinal axis of the structure 1. The adjacent end faces 3a, 4a and 5a of the panels 3, 4, 5 respectively, which constitute the modular body 2, have, in a position adjacent the wall 9, a longitudinal bevel edge 6 which extends over the whole longitudinal depth of the modular body 2. The longitudinal bevel edges 6

come into contact with each other when the modular body 2 is erected on site. Each panel which constitutes the modular body 2 is formed with a longitudinal rib 11 along each edge face turned towards the adjacent panels. Each longitudinal rib 11 has, in its central region, a recess 11a relative to the transverse ribs 10 so as to facilitate, in the erected structure, the passage of cables or ducts. The transverse ribs 10 of the panels 3 and 5 are provided with a pair of spaced apart edge flanges 12 extending over the entire length of the edge of the corresponding panel. The transverse ribs 10 of the central panel 4 are provided with a single edge flange 12 adjacent the wall 9 of the said panel.

Figures 8, 9, 10 and 11 illustrate a device designed to lift the modular body 2 in its pre-erection state shown in Figure 3, in order to raise it and deform it until it is made to assume the final conformation corresponding to that of its erection on site. The aforesaid device consists of two side-by-side cables 13, each of which has two straight end portions, a longer one 14 and a shorter one 15, and an intermediate portion connecting the two, indicated at 16. The two cables 13 are connected together by a connecting ring 17 interposed between the portions 15 and 16, and by two pulleys 18 interposed between the portions 16 and 14. The pulleys 18, possibly fitted with brakes, form part of a mechanism 19 designed to be grappled by a hook 20 and lifted by the latter. The longer straight end portions 14 of the cables 13 are connected at their free ends to the lateral panels 3 of the modular body 2. The shorter straight end portions 15 are on the other hand connected to the intermediate panels 5 of the said modular body 2. In this manner, elevation of the mechanism 19 causes a

raising of the said panels and finally of the entire modular body 2. The length and arrangement of the cables 16 are such that the action of the latter upon the body 2, combined with the force of gravity acting upon the various panels 3, 4, 5 which constitute the latter, is such as to cause relative rotation between the panels, bending the portions 7a of the connecting rods. This rotation, which occurs progressively as illustrated in the sequence of Figures 8, 9, 10 and 11, takes place around the straight line 8 which therefore constitutes an axis of articulation between the adjacent panels. In the final stage of this operation, the outer straight end portions 14 of the cables 13 rest upon a suitably pre-positioned reaction point 14a.

The contiguous panels rotate progressively until their facing longitudinal edges 6 come into contact with each other, as shown in Figure 11. The modular body 2 has then reached its final conformation and can therefore be installed alongside the other previously positioned modular bodies 2. Between the edges of the upper central panels 4 of the side-by-side modular bodies 2 a space 21 is formed which is open at the top and delimited below by the corresponding edge flanges 12. Between the facing edges of the adjacent panels 3 and 5 spaces 22 are formed which are closed and delimited by the corresponding edge flanges 12. Between the contiguous faces of the adjacent panels 3, 4 and 5 of each modular body 2 spaces 23 are formed which are open towards the outside and which are closed and delimited on the inside by the corresponding longitudinal bevels 6. Reinforcing rods indicated 24 are located on site in the said spaces 21, 22 and 23, and liquid concrete is then poured into the spaces 21 and 23, spreading within

the said spaces and into the spaces 22, and thereby achieving the monolithicity of the various modular bodies 2 to form a single structure 1. A concrete foundation 25 is also cast on site, by known methods.

The structure 1 thus produced consists of modular bodies 2 each formed from a single prefabricated element. In Figure 14, on the other hand, there is shown a structure 1, the modular bodies 2 of which consist of two contraposed prefabricated elements 2a, 2b connected together overhead at the centre of the modular body 2 (the elements 2a and 2b during erection and before interconnection are indicated by broken lines). Each prefabricated element 2a, 2b consists of three panels 3a, 4a, 5a and 3b, 4b, 5b respectively: the panels 3a and 3b form on site the lateral walls of the modular body 2; the panels 5a and 5b form the inclined sides and the panels 4a and 4b the upper sides of the covering wall of the modular body 2.

Naturally, while the principle of the invention remains the same, the forms of construction and operation may be widely varied relative to what has been described and illustrated, without nevertheless going beyond the scope of this invention.

For example, the portions 7a of the rods 7, instead of intersecting on the straight line 8, can be disposed so as to lie in a single plane parallel to the longitudinal axis of the structure 1 thus allowing, in this case also, the relative rotation of the panels upon erection.

Moreover, the panels, instead of being flat, may also

be provided with a curvature designed to form structures which have, at least partly, a curved shape.

Finally, the portions 7a of the reinforcing rods 7 may also be placed in proximity to the base walls 9 of the panels so as to form the articulation hinge between the contiguous panels in positions adjacent the inner concave surface of the structure 1. In this case the reciprocal positioning of the panels may be achieved by arranging, for example curved connecting rods and flexible elements which extend from one panel to the adjacent one in proximity to the free edges of the ribs 10: during erection the adjacent panels rotate relative to each other, causing progressive extension of the curved rods or of the flexible elements the length of which defines the final reciprocal position of the panels.

CLAIMS

1. Prefabricated support and covering structure particularly for making artificial tunnels, small bridges and the like, comprising a plurality of modular bodies, in the form of a polygonal sector, disposed side-by-side in succession along the longitudinal axis of the structure, characterised in that each modular body (2) is constituted by at least one prefabricated element comprising two or more panels of reinforced concrete (3, 4, 5) disposed in succession along the polygonal line which defines the cross-section of the prefabricated structure (1), each panel being connected to the adjacent panel by articulation means and means for reciprocal positioning, the articulation means consisting of a plurality of connecting rods extending from each panel to the adjacent panel.

2. Prefabricated structure according to Claim 1, characterised in that the connecting rods (7) of the adjacent panels of each prefabricated element extend from one panel to the next adjacent one, without interruption.

3. Structure according to Claim 2, characterised in that the intermediate portions (7a) of the connecting rods (7) between each pair of adjacent panels are inclined to each other and intersect on a common straight line (8) substantially parallel to the longitudinal axis of the structure, the said straight line forming an articulation hinge axis designed to allow, during erection on site, the relative rotation between adjacent panels which is necessary to bring the reciprocal positioning means into mutual contact.

4. Structure according to Claim 2, characterised in

that the intermediate portions (7a) of the connecting rods (7) between each pair of adjacent panels are disposed substantially in a single plane parallel to the longitudinal axis of the structure (1).

5. Structure according to Claim 3 or 4, characterised in that the connecting rods (7) extending between adjacent panels also extend within the latter, constituting reinforcing elements of the said reinforced concrete panels.

6. Structure according to Claim 5, characterised in that the connecting reinforcement rods (7), extending from each panel to the adjacent panel are disposed in proximity to the outer convex surface of the prefabricated structure and in that the reciprocal positioning means consist of a front edge (6) made upon each of the facing end faces of the adjacent panels, the said front edge being substantially parallel to the longitudinal axis of the prefabricated structure and disposed in proximity to the concave inner surface (9) of the latter, the two front edges (6) of each pair of adjacent panels being substantially in longitudinal contact with each other so as to constitute a reciprocal abutment and to define, with the respective adjacent surfaces of the said facing end faces (3a, 4a, 5a), a longitudinal space (23) filled with a binding material cast on site.

7. Structure according to Claim 6, characterised in that the panels of each modular body (2) have on their own lateral faces, which constitute on site the contact surfaces between the side-by-side modular bodies, lateral flanges (12), spaced apart and substantially

parallel to the polygonal line which defines the cross-section of the prefabricated structure (1), the said lateral flanges of one modular body (2) being substantially in contact upon erection with the corresponding lateral flanges of the neighbouring modular body so as to form a space (21, 22) extending parallel to the said polygonal line and interposed between the two adjacent modular bodies, the said space being filled with binding material cast on site.

8. Structure according to Claim 7, characterised in that each panel of each modular body (2) includes a base wall (9) which upon erection forms part of the inner concave wall of the prefabricated structure (1) and at least two transverse ribs (10) disposed in correspondence with and parallel to the two lateral edges of the panel, the said transverse ribs having upon their external lateral faces the lateral flanges (12) and upon their end faces the front edge (6) and the connecting rods (7) extending between adjacent panels.

9. Structure according to Claim 8, characterised in that each panel has, in correspondence with each of its front end surfaces which upon erection face an adjacent panel, a longitudinal rib (11) parallel to the axis of the prefabricated structure (1) and extending from one transverse rib (10) to the other, each end face of the panel having the connecting rods (7) extending between the corresponding transverse ribs (10) of the adjacent panels, and the front edge (6) extending along the longitudinal rib (11) between one transverse rib (10) and the next of the said panel.

FIG. 1

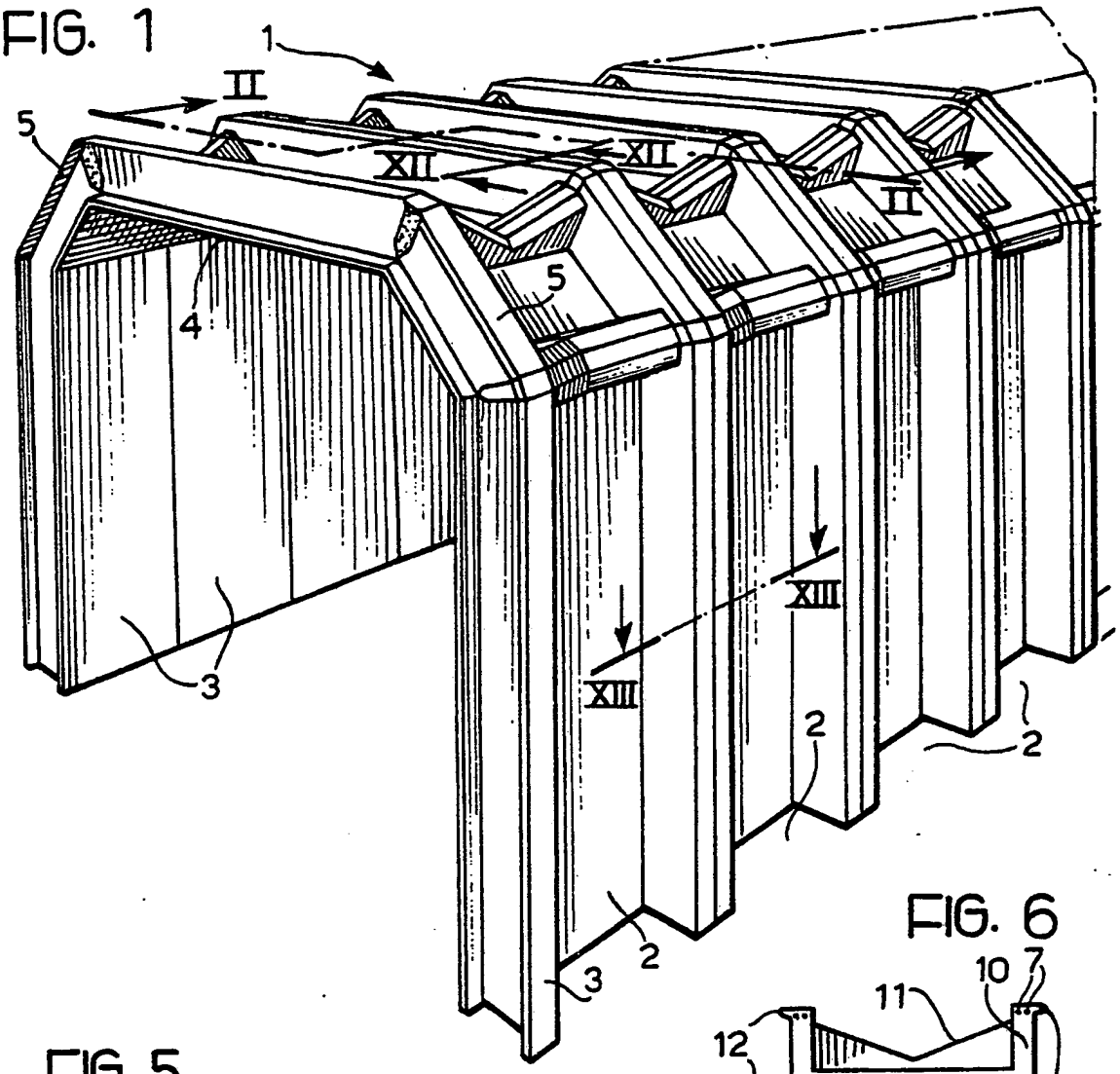


FIG. 6

FIG. 5

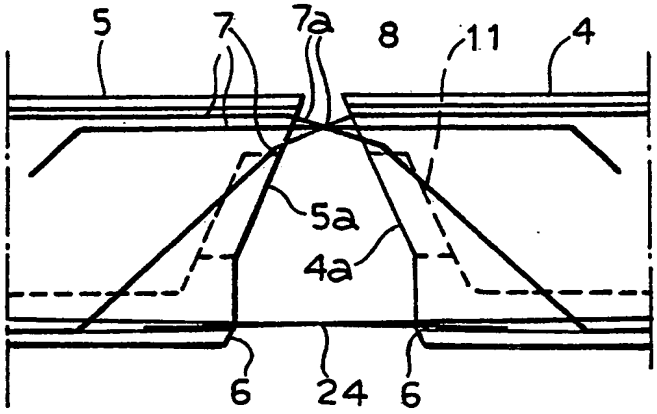


FIG. 7

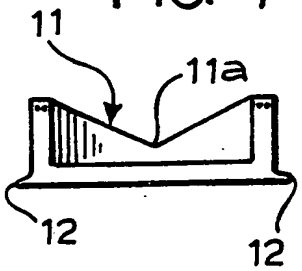


FIG. 2

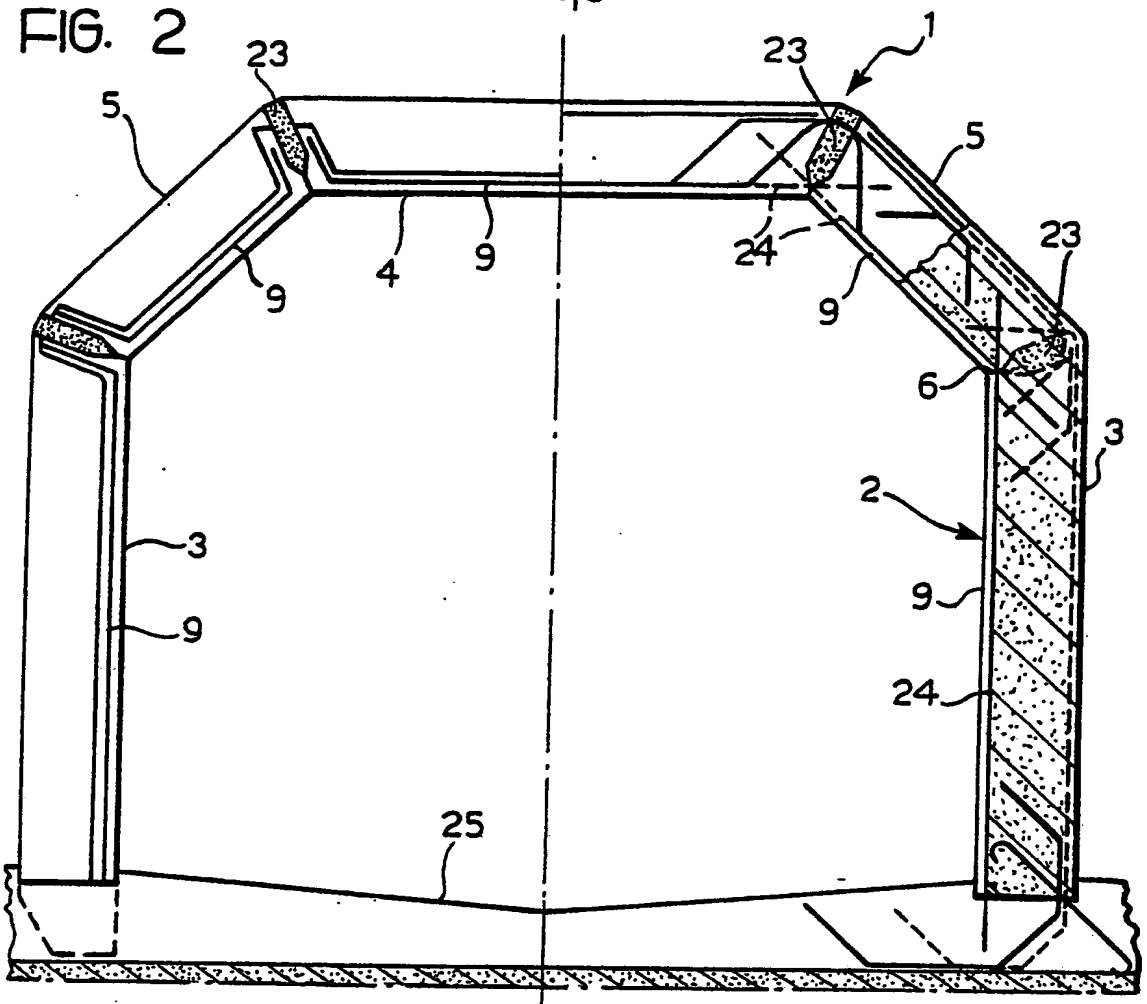


FIG. 12

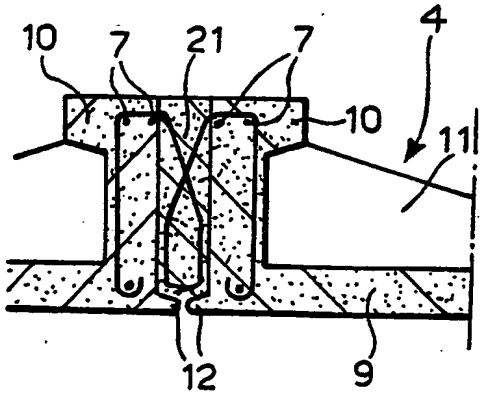
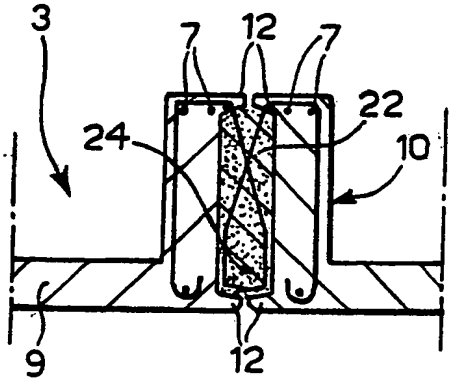


FIG. 13



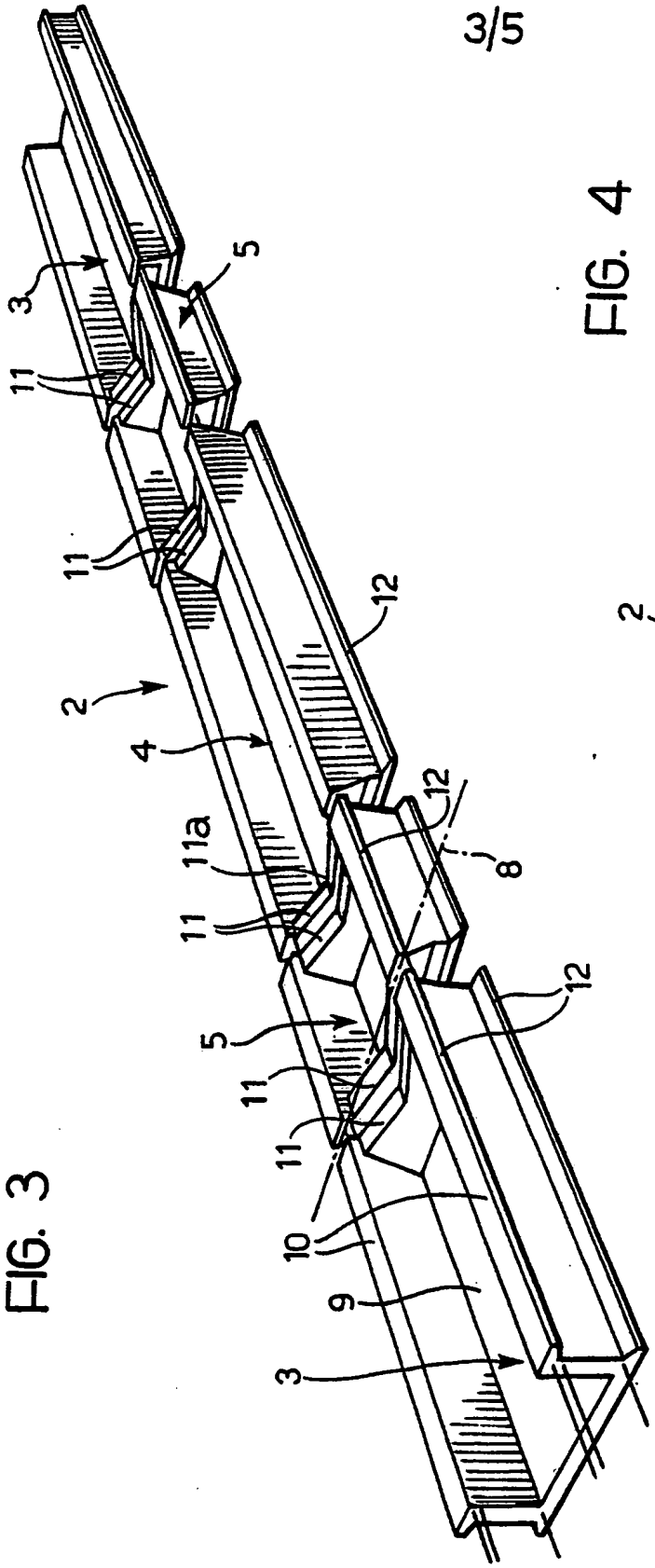

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FIG. 3

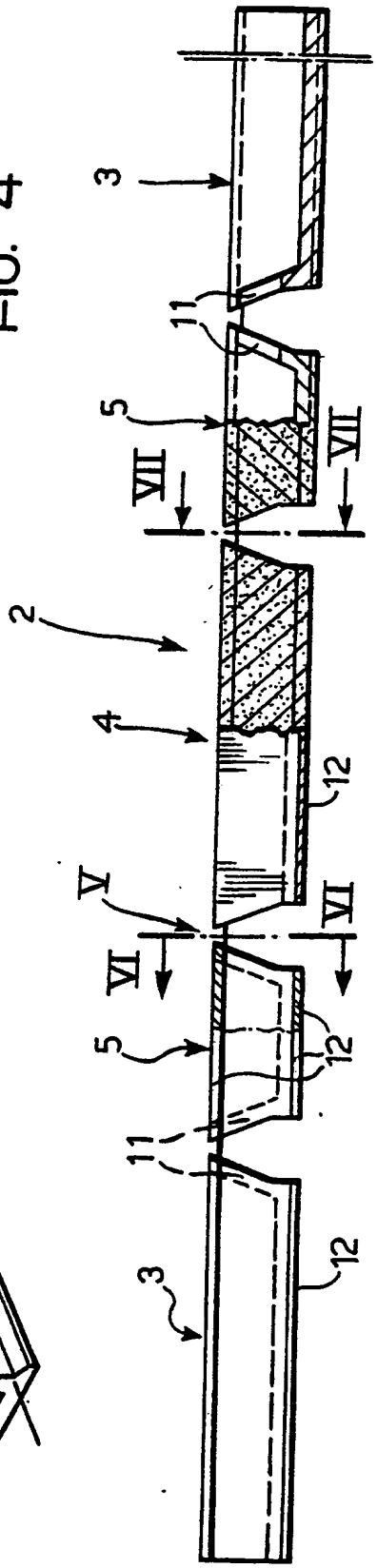
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FIG. 4

FIG. 8

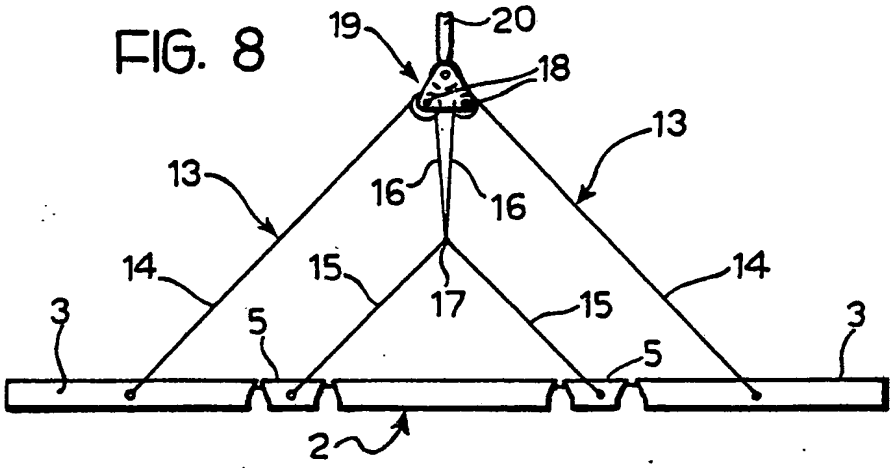


FIG. 9

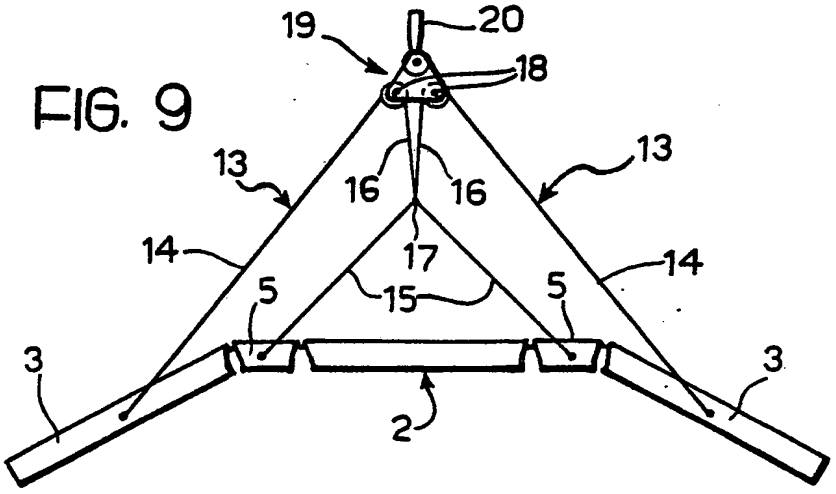


FIG. 10

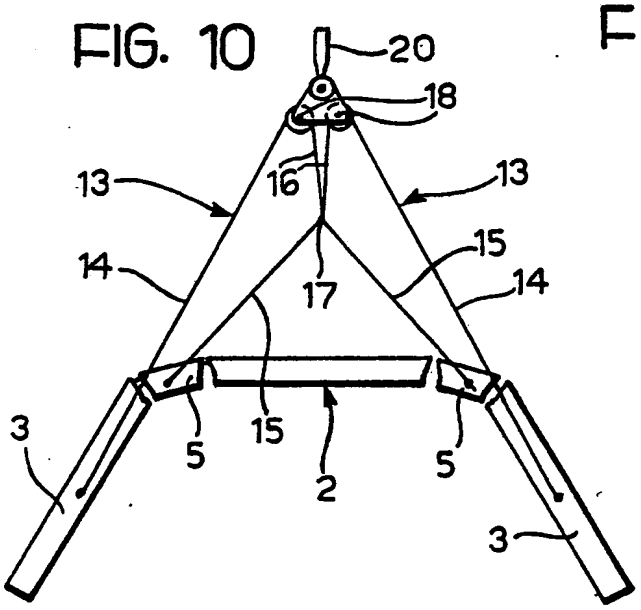


FIG. 11

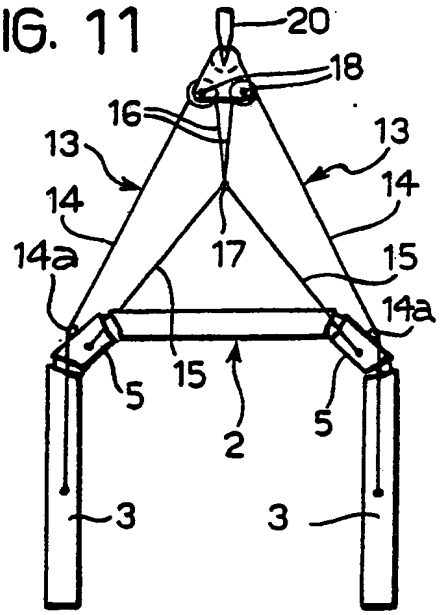
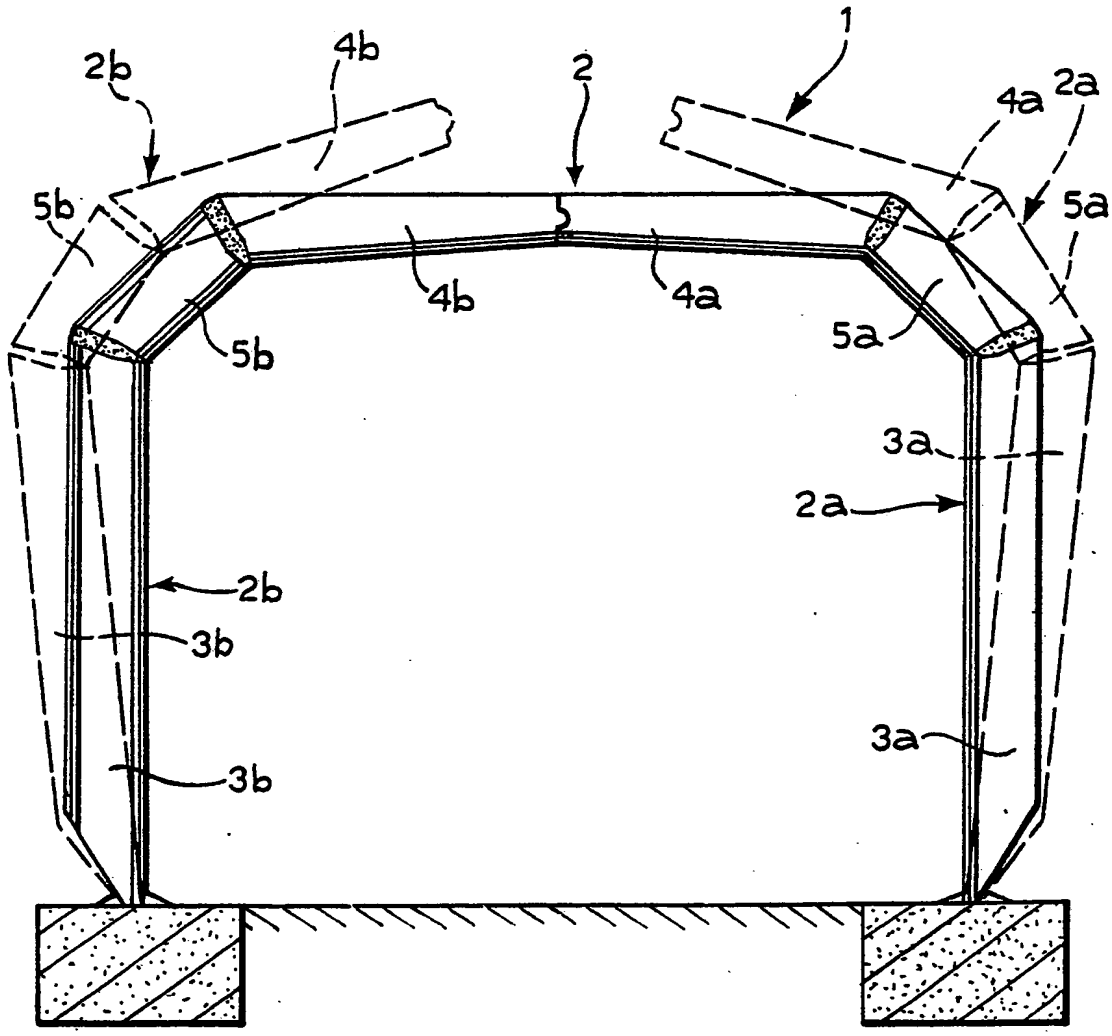


FIG. 14



INTERNATIONAL SEARCH REPORT

International Application No PCT/EP 85/00259

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[4]: E 21 D 11/08; E 04 B 1/344; E 04 B 1/18

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[4]	E 21 D E 04 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	US, A, 3854266 (SALAS) 17 December 1974, see column 5, line 54 - column 6, line 31; figures 1-5,9,10	1,2
Y	US, A, 3593482 (JOHNSON) 20 July 1971, see column 2, line 61 - column 3, line 27; figures 5,6	1,2
A		5,6
Y	US, E, 30929 (MAIMETS) 11 May 1982, see abstract; figures 1-3,7,8	1
A	DE, A, 1534627 (GRÜN & BILFINGER) 26 June 1969, see figures	3,4
A	US, A, 3834005 (JOHNSON) 10 September 1974, see figures 1-4	1,2
A	US, A, 3808754 (BOTTJER) 7 May 1974, see figures 2-4,9	1,2

* Special categories of cited documents: [10]

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"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
20th September 1985	09 OCT 1985
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	G.L.M. Kruydenberg

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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/EP 85/00259 (SA 10009)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 09/10/85

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 3854266	17/12/74	None	
US-A- 3593482	20/07/71	None	
US-E- 30929	11/05/82	US-A- 4124985	14/11/78
DE-A- 1534627	26/06/69	None	
US-A- 3834005	10/09/74	None	
US-A- 3808754	07/05/74	None	

EP861358

Publication Title:

EP0861358

Abstract:

Abstract not available for EP0861358
Abstract of corresponding document: US6129484

PCT No. PCT/EP96/04989 Sec. 371 Date May 12, 1998 Sec. 102(e) Date May 12, 1998 PCT Filed Nov. 17, 1996 PCT Pub. No. WO97/19231 PCT Pub. Date May 29, 1997A prefabricated structure for the construction of open air structures, particularly motorway flyovers, underpasses, bridges, tunnels, underground carparks and the like, includes a plurality of prefabricated elements of reinforced concrete. These elements are able to define the side walls and the deck of the work with adjacent longitudinal sections of the structure which rest on a foundation at the base of the work. Each section of the structure includes a pair of side elements which rest on the foundation via a static hinge and are intended to be disposed symmetrically with respect to the axle of the structure so as to assume a substantially L-shaped configuration. A substantially rectilinear prefabricated element is interposed centrally between two side elements and is anchored thereto so as to define a central portion of the deck of the work.